Achieving Emission Reduction Goals with Hydrogen

presented to

California Hydrogen Highway Network SB 76 Workshop
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Outline

- Societal Benefits Team Report
- GHG Reduction and Renewable Goals

The Societal Benefits Report included the contribution of over 30 individuals representing a broad range of organizations.

- SB report was 1 of 5 topic team reports
- Addressed energy impacts and emissions
- Developed goals

1. WTW Energy and Emissions Impact
2. Renewable Energy Sources
3. Challenges of CA Petroleum Dependency
4. Inclusion of Non-Hydrogen Technologies and Fuels

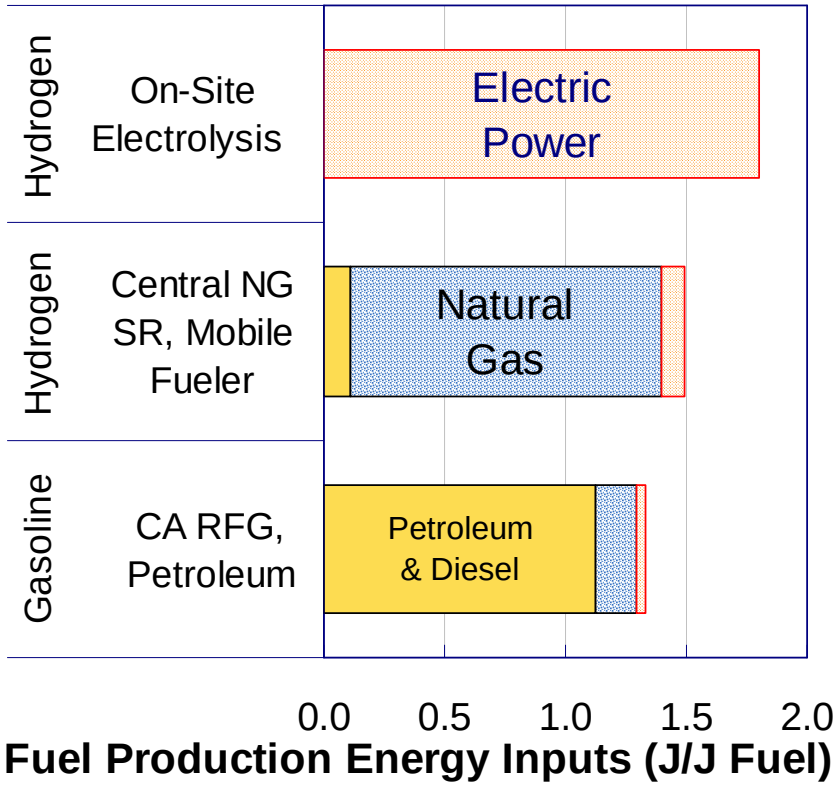
Societal Benefits Topic Team Report

California 2010 Hydrogen Highway Network

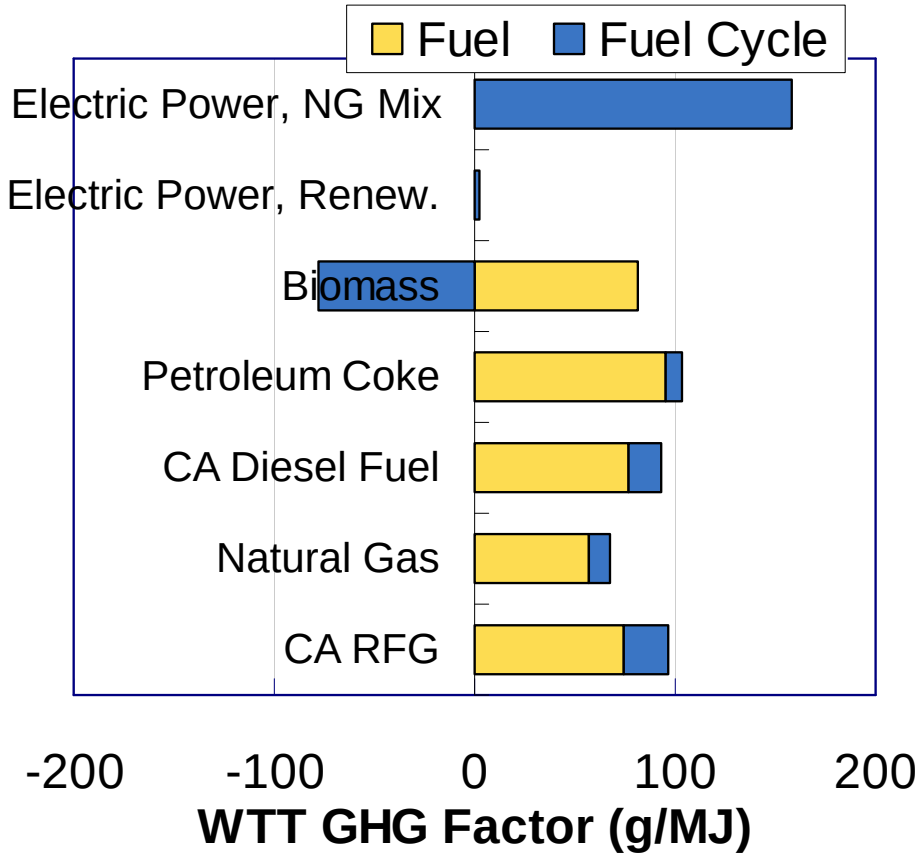
March 2005

The calculation of energy inputs, greenhouse gas, and criteria pollutant emissions are examined for a variety of hydrogen pathways .

Process Energy Inputs

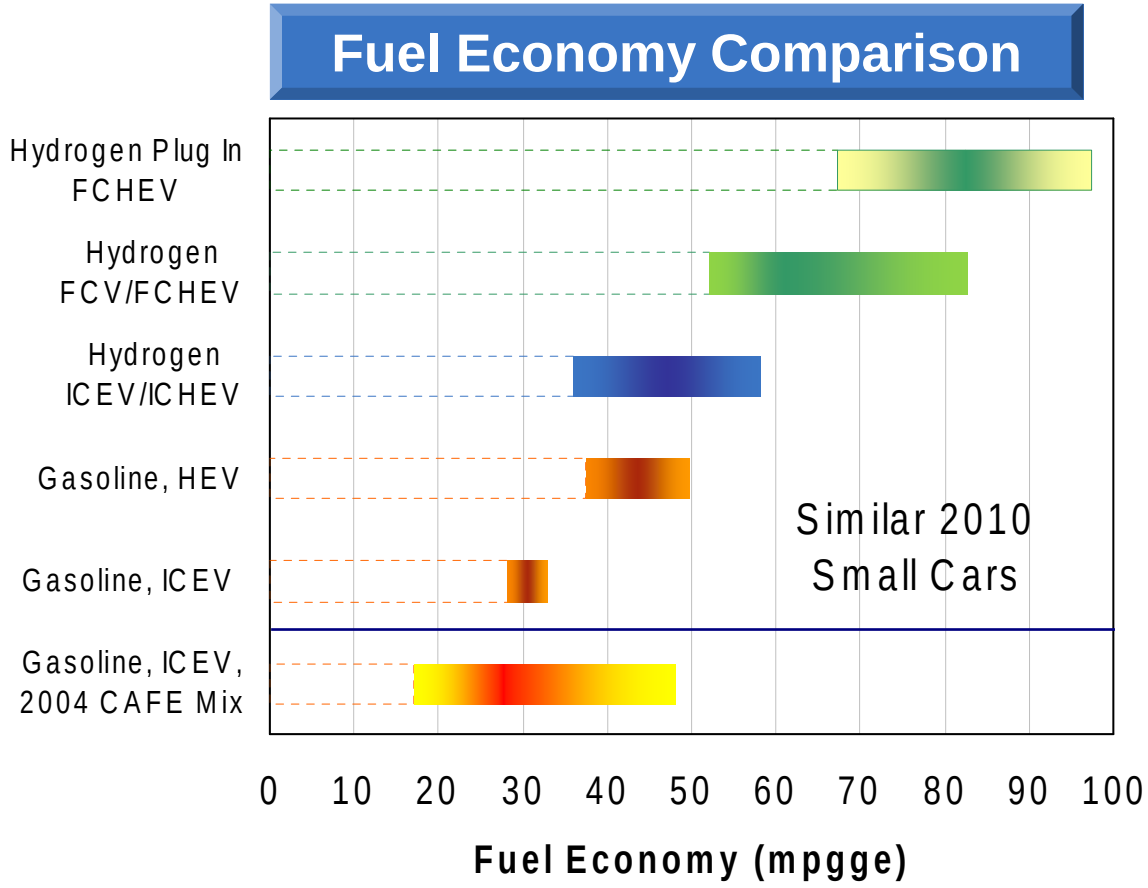


WTT GHG Factor



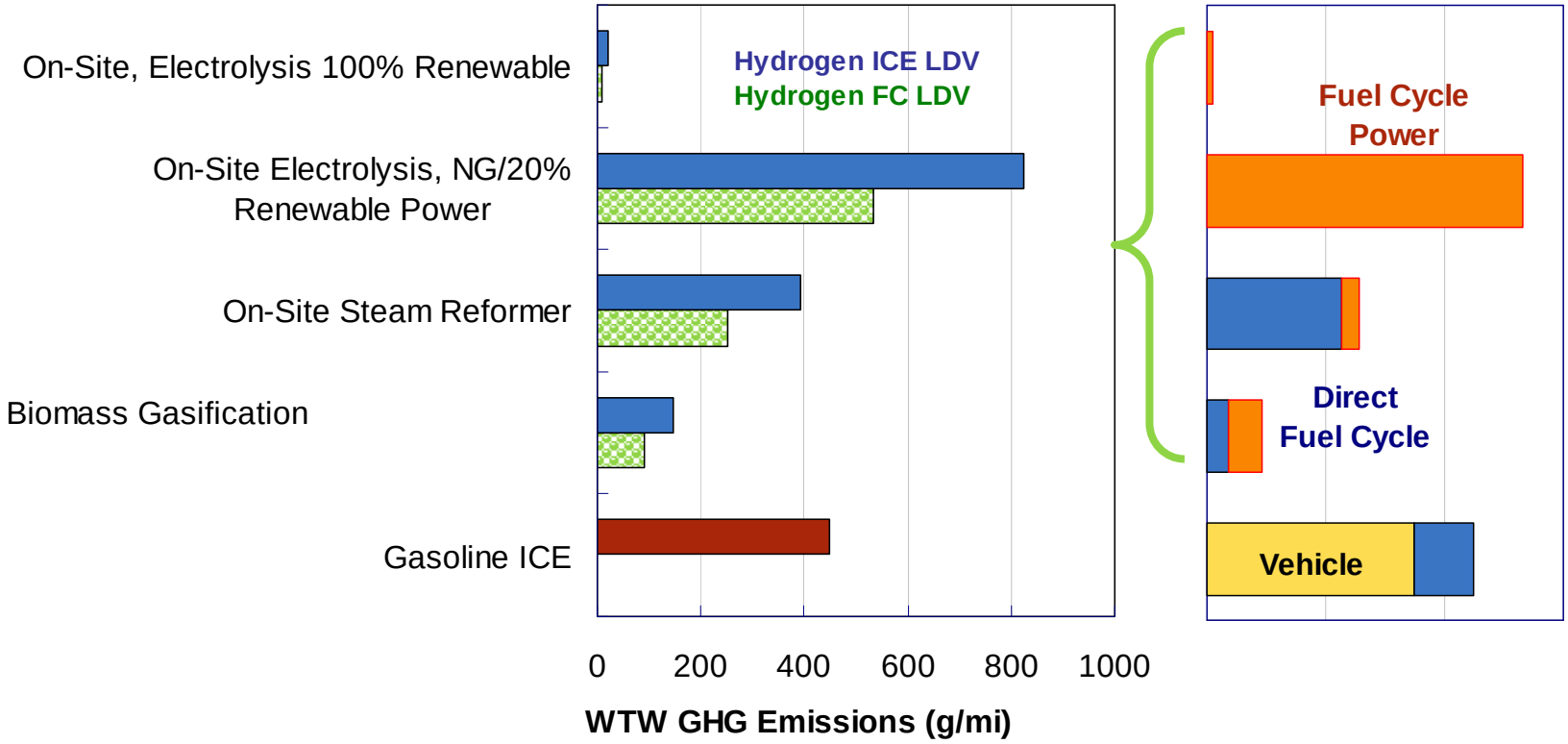
A vehicle fuel economy comparison was assumed for hydrogen internal combustion engine and fuel cell vehicles.

- Assumed energy economy ratio (EER) for comparable vehicle
  - 1.3 for ICEVs
  - 2.0 for FCVs
- Avoids comparison of dissimilar vehicles
- Avoids issue of conventional or HEV gasoline baseline
- Consider comparing vehicles in class



GHG emissions are the product of energy inputs and GHG factors combined with vehicle fuel economy.

Well to Wheel GHG Emissions for Passenger Cars



Blueprint Modeling Scenarios included station mix and and hydrogen capacity, which is matched with station mix model

Station Count by Forecourt Grouping

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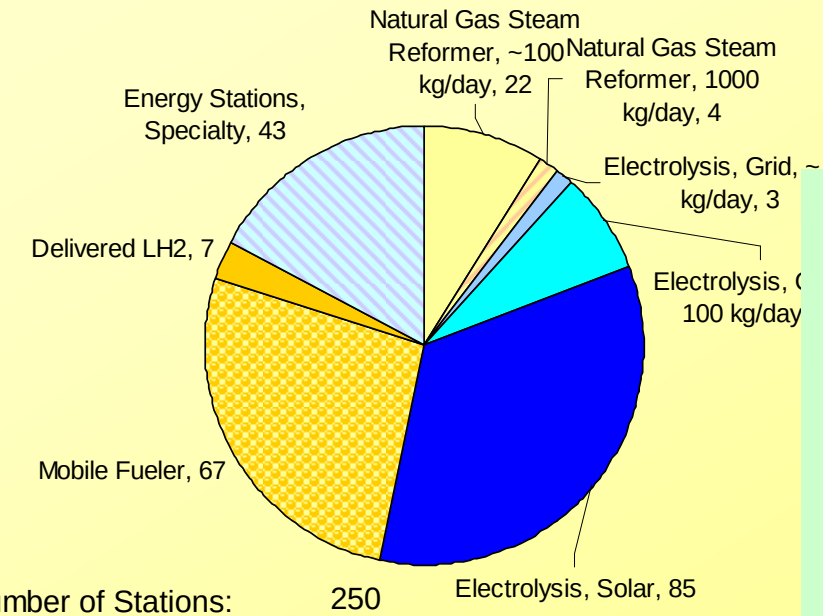
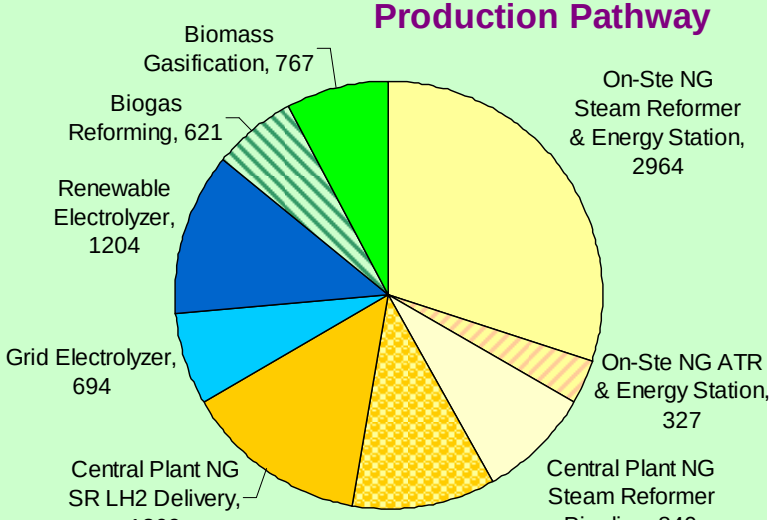


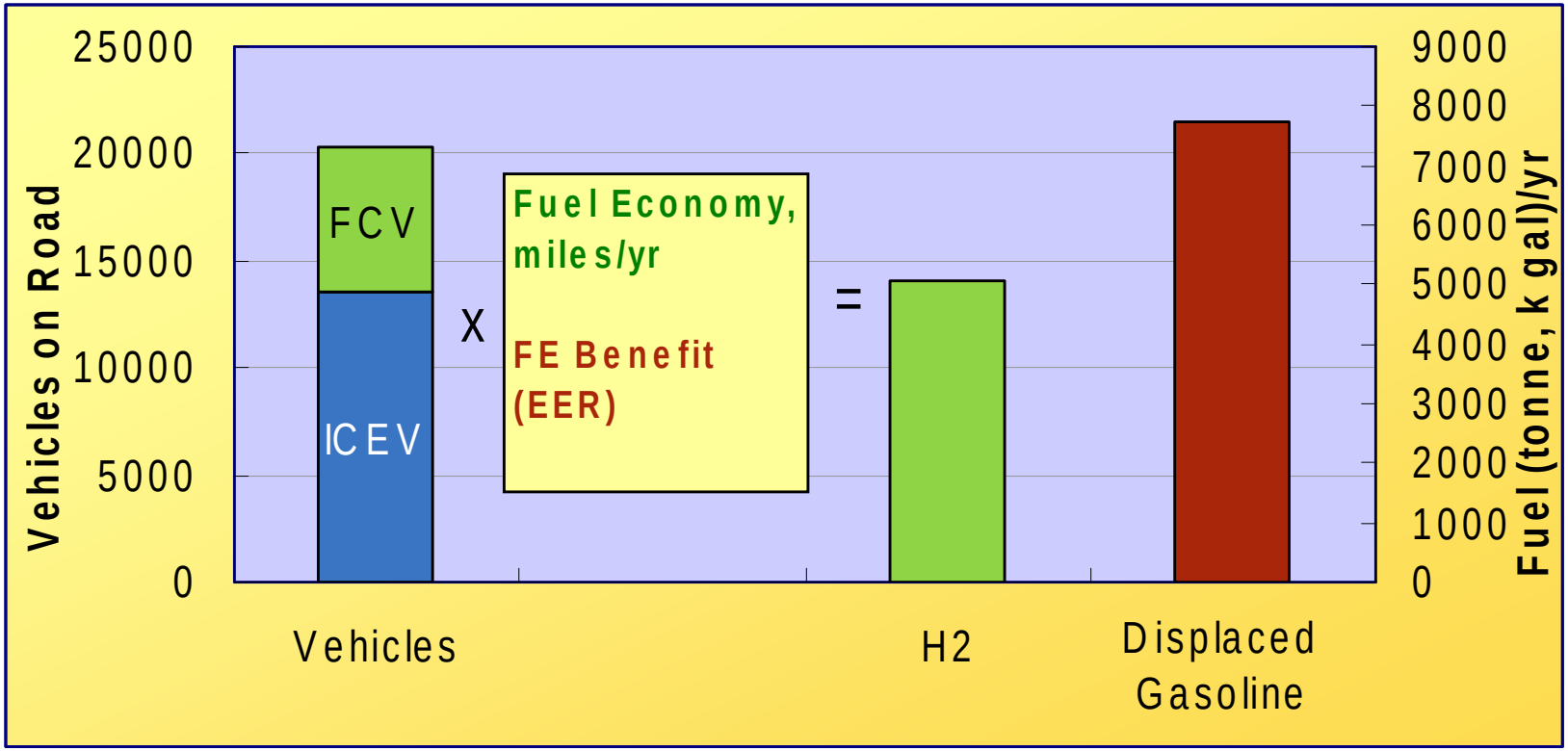
Number of Stations: 250

Hydrogen Capacity by Production Pathway



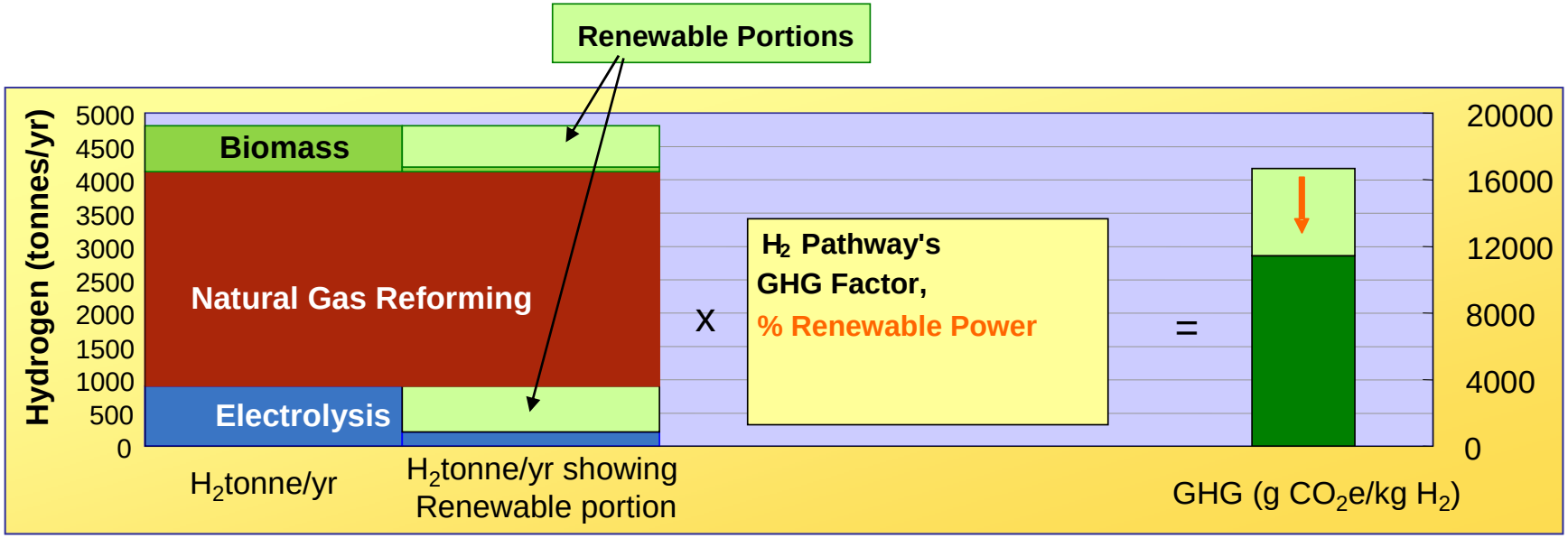
Production Mix, Tonnes/yr
Total Capacity: 9860

An aggregation procedure allows for the assessment of GHG emission reductions.



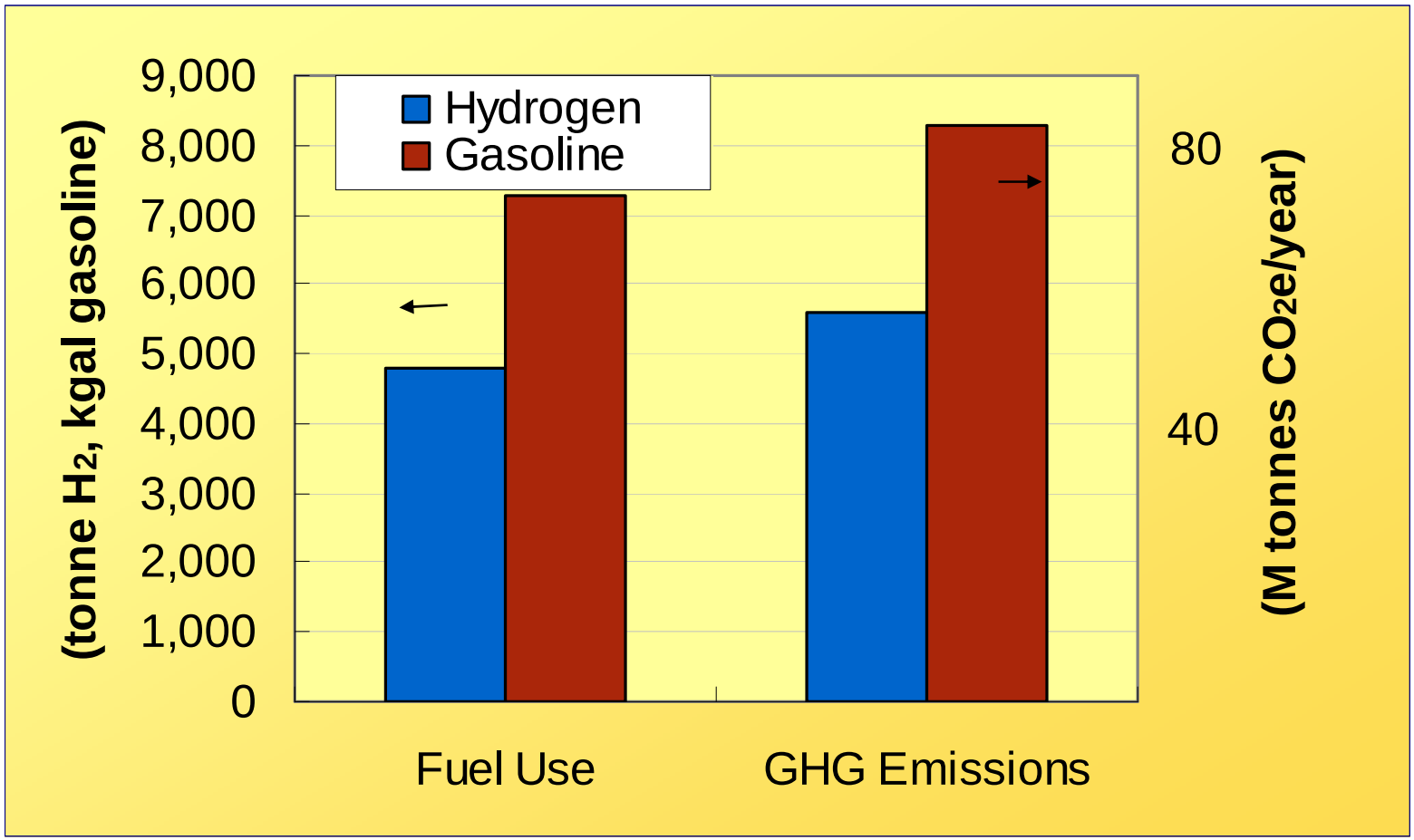
Scenario C estimated hydrogen demand for 20,000 Light-Duty Vehicles (12,000 ICEs, 8,000 FCVs)

Aggregate Well to Tank GHG is calculated from the production mix, GHG factors for each pathway, and the portion of electricity from renewable power



GHG factor includes Direct Emissions, Indirect Emissions from Power, Vehicle Emissions

GHG and Petroleum Displacement are calculated for a mix of hydrogen vehicles and associated production inputs.



SB 76 includes provisions for use of renewables and emission reductions from hydrogen.

"contribute to the achievement of the following energy and environmental goals by 2010:

(1) A 30 percent reduction in greenhouse gas emissions relative to comparable emissions from current-year vehicles.

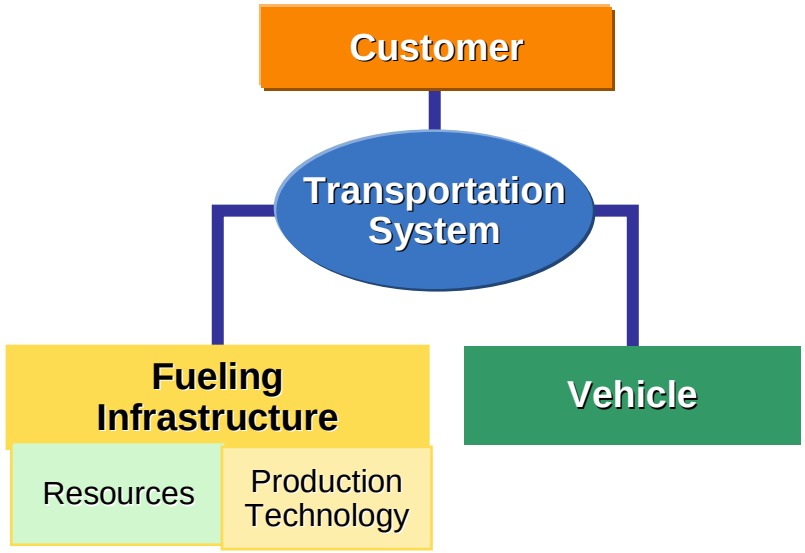
(2) The utilization of at least 33 percent new renewable resources in the production of hydrogen for vehicles.

(3) No increase in toxic or smog-forming emissions. "

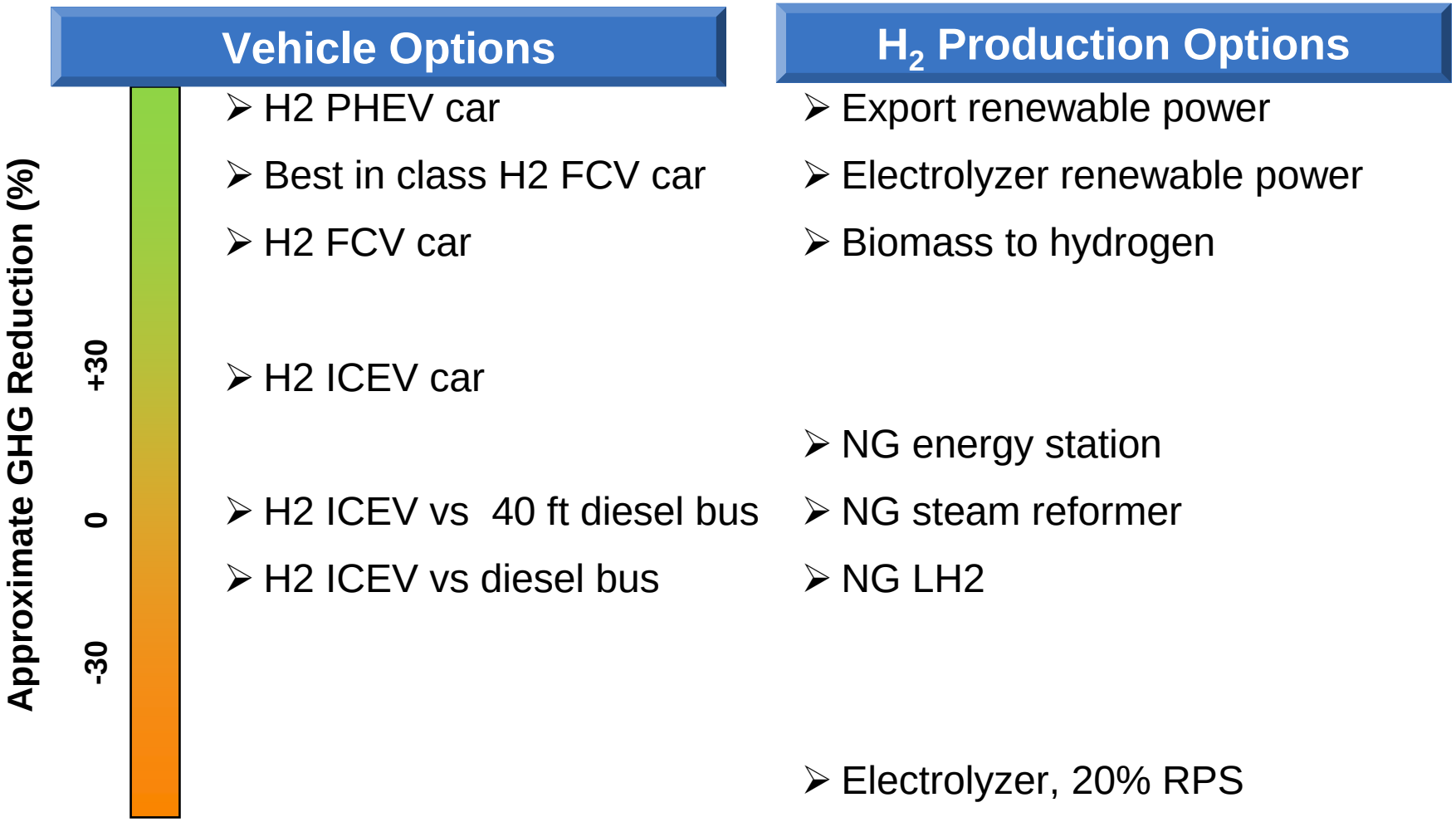
How can these goals be met?

Assuring reductions in GHG emissions requires integration between vehicle users.

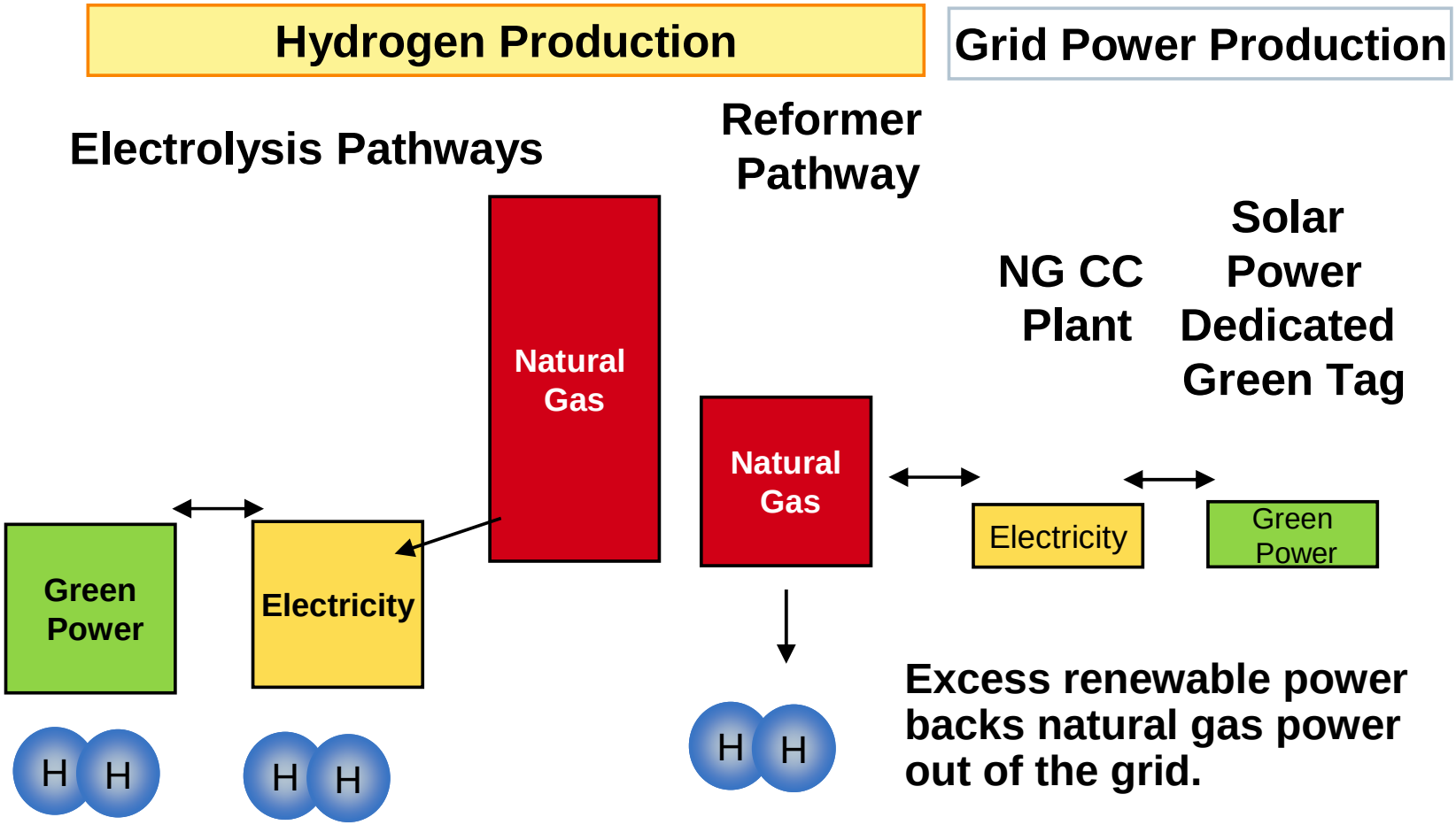
- Customer
  - What vehicles to buy?
  - How much driving?
  - Where to fuel?
  - SB76 vehicles at SB76 stations???
- Vehicle
  - Fuel economy
  - Emissions
- Fueling Infrastructure
  - Production pathways
  - Energy efficiency
  - Exported power
  - Use of renewables



Meeting GHG and renewable goals may be challenging for some scenarios.

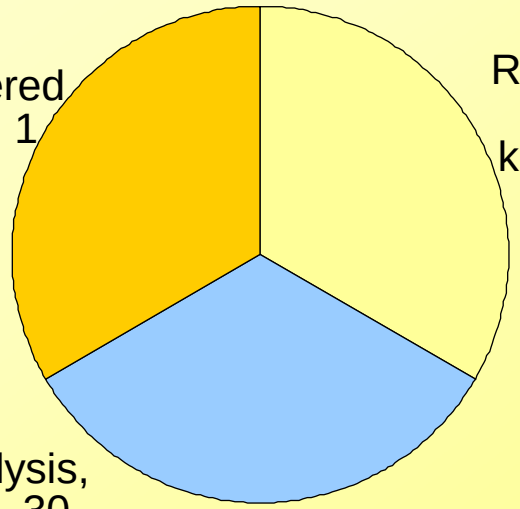


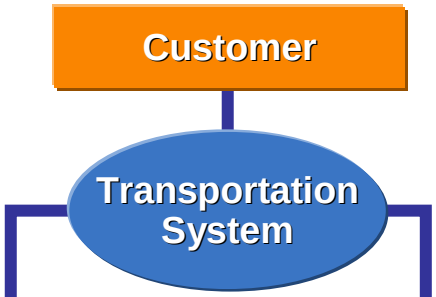
Hydrogen systems can use renewable power. Excess renewable power can also be provided back to the grid.

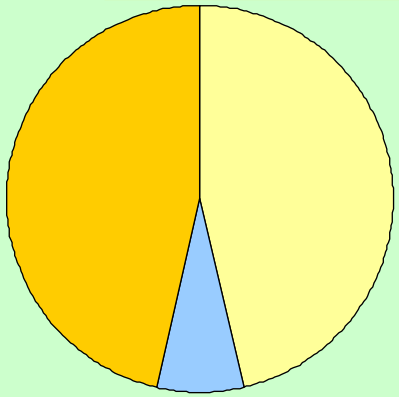


A scenario for fueling stations might include a diverse mix of technology options.

Station Count by Forecourt Grouping







Production Mix, Tonnes/yr
Total Capacity: 157

- 8 FCVs
- 4 ICEVs
- 2 ICE Shuttle Buses
- 4 tonne/yr H2 demand

For this scenario, assuming 20% renewable power for NG options and 70% renewable power for electrolysis options we fall short of the goals.

Assumptions

- H_2 capacity corresponds to example
- NG SR systems buy grid power
- No biomass or biogas derived hydrogen is available
- Electrolysis system buys 70% renewable power
- Assess impacts for 12 cars and 2 buses
- 2/3 of passenger cars are FCVs with 2x fuel economy improvement
- 1/3 of passenger cars are ICEVs with 1.3x fuel economy improvement
- H2 ICEV buses offer no fuel economy improvement over diesel

HERMIN Results

GHG Emission Reduction	14%
Renewable Hydrogen	20%
H_2 from New Renewables	12%
H_2 GHG Factor, g CO_2e/kg	14,000
Gasoline GHG factor, g CO_2e/kg	11,400
Reduced Fuel Usage	29%
Fuel Use Multiplier	1.41

However, hydrogen demand is only 0.4% of fueling station production capacity!

The GHG impact and use of renewables could be improved with more astute attention to fuel station and vehicle choices.

Solutions

- Select fuel station mix to include more biomass or renewable power
- Provide excess renewable power to the grid to back out natural gas used for hydrogen production
- Provide hydrogen vehicles with greater fuel economy improvement over vehicles that are replaced
- Broaden scope of GHG and renewables analysis to include more hydrogen FCVs

Several strategies could be used to achieve GHG and renewables goals.

- Let it ride

  Operate mix of vehicles and fueling stations. Examine energy and GHG impacts at the end of each month and buy renewable power/green tags to achieve goals.

  Adjust future vehicle and fueling station purchases to meet goals.

- GHG reduction plan

  Assess impact of vehicle and fueling station mix prior to implementation. Install or procure renewable capacity to achieve goals.

  Project fuel economy from vehicle options and set target for fueling stations.